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OBSERVATIONS ON THE NURSERY DEVELOPMENT OF SHORTLEAF PINE SEEDLINGS

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During a forest planting survey made by the Central States Forest Experiment Station in 1934, observations indicated that shortleaf pine may become one of the principal species to be used in reforesting extensive areas of eroding, submarginal lands found throughout the southern, unglaciated portion of the Central States. Many of the sites that once produced excellent stands of hardwoods have become so deteriorated by cultivation and erosion that only the less exacting coniferous species are likely to succeed, at least until favorable site conditions are restored to some extent by a cover crop of trees. Most northern and exotic conifers are poorly adapted to the conditions of soil and climate that make tree establishment difficult in certain portions of the Central States. Native species, such as pitch, Virginia, and shortleaf pine and red cedar are far better suited to this environment. Of these, shortleaf pine offers the greatest promise for most planting projects, particularly from the standpoint of profitable timber production, although the other native species may be better adapted to the poorest sites.

Shortleaf pine occurs naturally in this region in southern Ohio, in the eastern third of Kentucky, in scattered localities in Tennessee, throughout much of the Ozark region of northern Arkansas and southeastern Missouri, and in a very limited area in southwestern Illinois . It is usually found on residual sandstone soils on exposed slopes and excessively drained upland flats, or on chert-mantled ridges. Many of the older residents of these areas agree that the local distribution of shortleaf pine has been greatly extended in recent years by natural regeneration of seedlings in abandoned fields. Establishment of this species on poor, dry sites, under conditions unfavorable to most trees, indicates its probable success when planted.

It is generally recognized that the survival and establishment of a forest plantation is largely dependent upon the use of good nursery stock. Therefore, during the recent planting survey, particular attention was given to the methods and results of shortleaf pine seedling production in the various Federal, State, and private nurseries of the region as well as to the behavior of natural regeneration of this species. A brief summary of these observations may be helpful to nurserymen who have had little or no experience in growing shortleaf pine planting stock.

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Since the extensive planting operations of the region must be undertaken on sites quite xerophytic, it is necessary to produce seedlings which will give the highest percentages of survival and establishment. To accomplish this, special consideration must be given to such characteristics of seedlings as shoot-root ratio, degree of succulence, and size of stock. The nursery practices which control these characteristics to the greatest extent are shading, watering, selection of seedbed soil, density of seedlings, length of time left in seedbed, and fertilizing.

Shading. The response of shaded seedlings to the factors of their environment after planting is often less favorable than that of seedlings developed under conditions of the planting site. It is apparent that the almost universal shading of coniferous seedbeds without regard to species, as practiced by a few nurserymen, is a "hangover" from the production of seedlings of species exotic to the region; e. g., spruces, Norway pine, firs, larches, etc. It is common experience in this region that without shade during the first season there is a very high rate of mortality of these exotics. The loss is particularly heavy on sandy soils and may be attributed to excessive heating at the soil surface, and, to a lesser degree, to the long periods of exposure to direct sun rays. Where old plantations or individual trees of these exotics are found in the region, very little or no reproduction occurs under conditions where shortleaf pine reproduces abundantly. This partially explains the limit placed upon the southern extension of some of the northern conifers and other species.

Although shading does conserve soil moisture, no nurseryman seems to be able to justify the shading of shortleaf pine seedlings. On the contrary, nurserymen who have been producing planting stock of this species in open beds for the last four or five years have discontinued the use of shades. Without shade, the shoot-root ratios are lowered, which mean lower ratios between water transpired and water absorbed; also, they find less succulent foliage and stems more resistant to the direct rays of the sun, low winter temperatures, and late spring frosts after dormancy is broken. Plantings on the Central Division of the Ozark National Forest in Arkansas, made from 1-0 stock grown in both open and shaded beds at the Forest Service Nursery at Russellville, show better survival with the unshaded seedlings. The planting experience of the region further substantiates the preference for unshaded seedlings.

Watering. It is imperative that the amount of water applied to seedbeds during the growing season be controlled to obtain desirable planting stock. Watering should correspond closely to the rainfall which the seedlings normally receive under field conditions. This practice, with certain modifications, is being conducted in several nurseries in the Central States. If the soil moisture at the time of seeding is somewhat low, sprinkling is done to insure maximum germination and early growth. Later in the season there may be critical periods of drought when watering is necessary to maintain a suitable growth rate. The danger in too frequent watering arises from producing high shoot-root ratios and increased succulence, characteristics common to shaded seedlings. The behavior here is largely due to increased availability of the essential mineral elements.

Soil Conditions. Within the climatic range of shortleaf pine, soil moisture and temperature seem to be important in limiting its natural distribution to certain areas of sandy or cherty soils. The extremely low moisture content of these well-drained soil materials during the dry seasons is less favorable for the survival of hardwood than pine seedlings. The competition between the broadleaf species and the intolerant shortleaf pine is thereby reduced; and if seed of the pine is available, a stand frequently develops. Also, shortleaf pine seedlings are damaged less than many of the hardwood seedlings by frequent high temperatures at the surface of sandy and rocky soils.

While not all the soil factors which are significantly correlated with good sowing and planting practices are known, it is in well-drained, sandy loam seedbeds that the best nursery results are obtained. Often it is advisable to improve the physical condition of soils high in colloids by rotation of some green manure crop with a crop of seedlings. Sometimes two green manure crops are plowed under in a single season; e. g., an early crop of rye followed by soy beans. Oats, cowpeas, sweet clover and buckwheat are also used.

Age of Seedlings. The age of shortleaf pine seedlings planted in the region depends at present somewhat upon the size, which varies with the increase in length of growing season from north to south. In general, planters in the northern half of the region prefer 1-1 stock, even when orders are placed with southern nurseries where size is expected to be greater than that of locally grown material. In the northern nurseries where seedlings are grown under shades, 5 to 10 inches seem to be the maximum heights attained in one year. In the southern half of the region, where 10 to 12-inch seedlings develop in one season, most planters prefer 1-0 stock. Shortleaf pine planting stock should not be more than two years old for field planting, since the roots of the larger seedlings are damaged in handling. The use of unnecessarily large planting stock is costly and increases the risk of unsatisfactory tree development. It is suggested that quality of stock and not size should be given most consideration. While excellent survival has been realized by planters of 1-1 stock in Kentucky, Ohio, and Illinois, it is thought that good success may be obtained with properly grown 1-0 stock when the ground cover is not too tall and dense, in which case even 1-1 seedlings are often suppressed. The development of an adequate root system during the shorter growing season in the north may be the criterion. Should the planting of the smaller 1-0 seedlings prove satisfactory in the northern sections of the unglaciated area, there is the added advantage of cheaper production.

Rate of Seeding. Rate of seeding in beds varies appreciably, and often may be a limiting factor in the production of high quality stock. Certain factors, such as viability, size, and purity of seed, quality of seedbed soil, method of sowing (broadcast or drilling), and length of time seedlings are to be left in beds, control rate of seeding. Few of these need any discussion. As the quality of seedbed soil decreases the amount of seed per unit area may be slightly increased, because of the

less crowded condition among the smaller plants produced. When broadcast sowing is practiced, the rate of seeding may be increased over that of drilling. Drilling is usually preferred, especially when seed is distributed in ribbon-like bands by drills and not concentrated in bottoms of V-shaped drill rows, because of uniform depth of covering of seed, ease of cultivation, weeding, and lifting. In a few nurseries the plants are left in the seedbeds for two years. When this practice is followed, fewer seed must be sown. Where 1-1 stock is desired, it is usually transplanted in the late autumn of the first season or before breaking of dormancy the second season, autumn transplanting being the more common. Where seed is drilled, eight rows to the 4-foot bed, either by a seeder or by hand, thirty to forty 1-0 seedlings per square foot may be expected as an average crop. In some nurseries as high as sixty seedlings are grown per square foot. Usually from 4 to 8 ounces of seed per 100 square feet of seedbed area are sown.

It is often desirable for the nurseryman to have available some simple method of determining the quantity of seed to sow per unit area of seedbed. Below is a simple formula used by Philip Bryan at the Ozark National Forest Nursery, Russellville, Arkansas, as reported in the Ozark Nursery report for 1933.

Formula: $O = \frac{AD}{GSZ}$

O = ounces of seed to sow

A = area of beds in square feet

D = density desired per square foot

G = germination per cent of seed

S = number of seed per ounce

Z = varying factor, an expression of allowance for damping-off, and for difference in seedbed and laboratory germination tests. (Bryan uses a factor of .3.)

Source of Seed. While there has been only limited investigation of the success of shortleaf pine seedlings grown from locally produced seed and from seed produced under different climatic conditions, experience with this and other species indicates that locally grown seed should be used. Several instances in the northern part of the region have shown stock developed from southern seed to be much more susceptible to frost injury than that from seed collected locally. No information is available regarding the quality of stock grown in the south from northern seed, or of stock produced from seed collected in different latitudes. As a rule, the use of local seed is safest.

Control of Damping-off Fungi. Shortleaf pine seedlings are not so susceptible to damage by damping-off fungi as are many other species, probably because of quick germination and rapid early growth. Good nursery practices are unfavorable to the development of these parasitic organisms. Early plowing and working of the soil, followed by thorough discing and harrowing at intervals, during which the soil is exposed to long periods of full sunlight, destroy many germinating spores and fully developed mycelia. Furthermore, a well-prepared bed is sufficiently aerated to retard damping-off fungi. Omission of frames and shades from

the beds lowers the relative humidity at the soil surface, a condition less favorable for the fungous growth than higher humidities. Limiting the amount of water applied to beds sufficient to insure good germination reduces chances for severe infections. Surface application of compost or leaf litter, made to increase organic matter of the soil and to conserve moisture, is a practice usually favorable to damping-off fungi and should be dispensed with when possible. When difficulty from damping-off is experienced by failure to control the physical conditions of the environment, damage may be minimized by one of these methods: (1) Apply 8 to 12 ounces of sulfuric acid per 100 square feet soon after sowing. The commercial grade is as effective as chemically pure acid. (2) A powdered charcoal-formalin mixture may be dusted over the seedbed before or after sowing at the rate of 65 to 100 ounces to 100 square feet of seedbed. The mixture should contain 6% of a 40% solution of formaldehyde, an inexpensive preparation. (3) Before sowing, approximately 50 gallons of a 3% solution of formaldehyde may be sprinkled over 100 square feet of seedbed, which is then covered with burlap or paper, and left for three or four days before sowing. This may be ineffective unless sterilized tools and sterilized seed are used. (4) Semesan may be used for dusting seed previous to sowing. (5) Cuprocide (cuprous oxide), a commercial seed protectant, may be used for dusting seed before sowing.

Fertilizing. Definite information regarding the use of commercial fertilizers and their effects upon shortleaf pine seedlings is not available. Several projects, designed to furnish needed information, are in progress in the region. Since the species reproduces and grows moderately well on poor, abandoned field soils, the necessity for heavy applications of fertilizer is questionable. This is further indicated by the usual small response of conifers to variations in quantities of essential mineral elements, as compared with that of hardwoods. Fertilizers which are low in nitrogen are most commonly used. Perhaps, the danger of producing undesirable succulent plants with high shoot-root ratios from fertilizing is not as great as among the hardwood species; but since available essential mineral elements are necessary for the growth of all green plants, deficiencies of one or many of them must not be overlooked. Since these vary with individual nursery sites, general rules for fertilizing are of little value. A half and half mixture of bone meal and acid phosphate, 12.5 pounds per 100 square feet of seedbed, or a 5-8-7 commercial mixture, approximately 1.8 pounds per 100 square feet of seedbed, have been recommended.

To correct a chlorotic condition in seedlings, spray the leaves with a manganese sulphate solution, 8 parts manganese sulphate per million parts of water; increase the magnesium in the soil by the addition of small quantities of pulverized dolomitic limestone; or spray a 1% solution of ferrous sulphate on the leaves, sufficient to wet.

The production of well balanced seedlings having sturdy, well lignified stems and well developed, compact root systems, is a problem confronting each nurseryman for his particular site conditions. Desirable stock is the result of not one or two site factors, but of a complex of factors operating in varying intensities and proportions from time to time and from site to site. Even with the production of good nursery stock, unless seedlings are properly handled from the lifting operation to the completion of the planting job, satisfactory results will not be obtained.